WHAT IS CLAIMED IS:

1. In a system in which a boring tool is moved underground in a region during selective rotation of the boring tool, a method comprising the steps of:

configuring the boring tool with a transmitter for transmitting a locating signal for use in tracking an underground position of the boring tool in said region and for changing at least one characteristic of said locating signal responsive to subjecting the boring tool to a predetermined roll sequence during underground operation such that the predetermined roll sequence includes the steps of rotating the boring tool for one time period at a first roll rate in timed relation to rotating the boring tool for another time period at a second roll rate.

2. The method of claim 1 wherein said boring tool is rotated at said second roll rate immediately following rotating at said first roll rate without stopping rotation of the boring tool between the first and second roll rates.

3. The method of Claim 2 wherein said predetermined roll sequence includes the step of ceasing rotation of the boring tool for a predetermined interval prior to one of said first and second time periods.

4. The method of Claim 2 wherein said predetermined roll sequence includes the step of ceasing rotation of the boring tool immediately following said second time period for a predetermined interval.

5. The method of Claim 1 wherein said detecting step includes the steps of (i) determining a change in roll position over an interval of time during which the boring tool rotates, (ii) comparing the change in roll position to a threshold value and (iii) selecting an interval roll rate for that interval of time as one of the first roll rate and the second roll rate based on the comparison step.

6. The method of claim 1 wherein the first roll rate is a slow roll rate relative to the second roll rate.

7. In a system in which a boring tool is movable underground in a region during selective rotation of the boring tool using a drill string, a method comprising the steps of:

configuring the boring tool with a transmitter for transmitting a locating signal for use in tracking an underground position of the boring tool in said region and for changing at least one characteristic of said locating signal responsive to subjecting the boring tool to a predetermined roll sequence during underground operation, said characteristic being selected as at least one of frequency of the locating signal and transmitted power of the locating signal;

selectively rotating the boring tool using the drill string to subject the boring tool to the predetermined roll sequence, said predetermined roll sequence including the steps in the order of

for a first time interval, maintaining a non-roll status of the boring tool,

rolling the boring tool at a slow roll rate for a second, slow roll rate time interval,

rolling the boring tool at a fast roll rate for a third, fast roll rate time interval without stopping rotation following the slow roll rate time interval, and

for a fourth time interval, again maintaining the non-roll status of the boring tool.

8. The method of claim 7 wherein said first through fourth time rate intervals are of approximately equal time duration.

9. In a boring tool for use in a system in which the boring tool is moved underground in a region during selective rotation of the boring tool, an assembly comprising:

a first arrangement for transmitting a locating signal from the boring tool for use in tracking an underground position of the boring tool in said region; and

a second arrangement, cooperating with said first arrangement, for changing at least one characteristic of said locating signal responsive to subjecting the boring tool to a predetermined roll sequence during underground operation including rotation of the boring tool for one time interval at a first roll rate in timed relation to rotation of the boring tool for another time interval at a second roll rate.

10. The assembly of claim 9 wherein said roll detection arrangement is configured for detecting the second roll rate interval immediately following the first slow roll rate interval without stopping rotation of the boring tool between the first and second roll rate intervals as part of said predetermined roll sequence.

11. The assembly of Claim 9 wherein said roll detection arrangement is configured for detecting a non-roll interval immediately prior to one of said first and second roll rate intervals.

12. The assembly of Claim 9 wherein said roll detection arrangement is configured for detecting a non-roll interval immediately following one of said first and second roll rate intervals.

13. The assembly of Claim 9 wherein said roll detection arrangement is configured for (i) determining a change in roll position over an interval of time during which the boring tool rotates, (ii) comparing the change in roll position to a threshold value and (iii) selecting an interval roll rate for that interval of time as one of the first roll rate and the second roll rate based on the comparison step.

14. The assembly of claim 9 wherein the first roll rate is a slow roll rate relative to the second roll rate.

15. A transmitter configured for installation in a boring tool, said transmitter comprising:

a first arrangement for transmitting a locating signal at a selected one of at least two frequencies; and

a frequency selection arrangement, cooperating with said first arrangement, for determining the selected one of said frequencies based, at least in part, on a pitch orientation of the transmitter.

16. The transmitter of claim 15 wherein said frequency selection arrangement determines the selected one of said frequencies responsive to the pitch orientation of the transmitter upon power-up of the transmitter.

17. The transmitter of claim 15 having an elongation axis and a forward end for installation in a boring tool wherein said frequency selection arrangement includes a pitch sensor for measuring pitch of the transmitter with respect to the elongation axis.

18. The transmitter of claim 17 wherein said first arrangement is configured for transmitting at a low frequency and a high frequency and wherein said frequency selection arrangement is configured for selecting the high frequency upon power-up of the transmitter with the forward end of the transmitter pointing approximately upward.

19. The transmitter of claim 17 wherein said first arrangement is configured for transmitting at a low frequency and a high frequency and wherein said frequency selection arrangement is configured for selecting the low frequency upon power-up of the transmitter with the forward end of the transmitter pointing approximately downward.

20. The transmitter of claim 15 wherein a low one of said frequencies is approximately 1.5 kilohertz.

21. A transmitter configured for installation in a boring tool, said transmitter comprising:

a first arrangement for transmitting a locating signal at a selected one of at least two frequencies for use in tracking the boring tool; and

a frequency selection arrangement, cooperating with said first arrangement, for determining the selected one of said frequencies based on an orientation parameter of the transmitter at power-up of the transmitter.

22. The transmitter of claim 21 wherein said frequency selection arrangement includes a pitch sensor for measuring pitch of the transmitter as said orientation parameter.

23. A transmitter configured having an elongation axis and a forward end for installation in a boring tool, said transmitter comprising:

a first arrangement for transmitting a locating signal at a selected one of at least two frequencies for use in tracking the boring tool; and

a frequency selection arrangement, cooperating with said first arrangement, for switching the selected one of said frequencies to another one of said frequencies responsive to detecting a pitch orientation sequence to which the transmitter is subjected.

24. The transmitter of claim 23 wherein said frequency selection arrangement includes a pitch sensor for measuring the pitch orientation of the elongation axis of the transmitter.

25. The transmitter of claim 23 wherein said frequency selection arrangement is configured for detecting, as said pitch orientation sequence, a first time interval during which the elongation axis of the transmitter is in a first pitch orientation, a second time interval during which the elongation axis is oriented having a second, different pitch orientation and a third time interval during which the elongation axis is oriented having a third pitch orientation.

26. The transmitter of claim 25 wherein the first and third pitch orientations are approximately equal.

27. The transmitter of claim 26 wherein the first and third pitch orientations are approximately horizontal.

28. The transmitter of claim 25 wherein the second pitch orientation is 45 degrees or more above horizontal.

29. The transmitter of claim 25 wherein the frequency detection arrangement is configured for detecting the first, second and third time intervals each including a duration that falls within a specified duration interval range.

30. The transmitter of claim 23 wherein said frequency selection arrangement is further configured for detecting the selected one of said frequencies as a power-down frequency at a time when the transmitter is transferred from an operational state to a shutdown state and for restarting in the operational state at the power down frequency.

31. A transmitter configured for installation in a boring tool, said transmitter comprising:

a first arrangement for transmitting a locating signal having a selected one of at least two frequencies for use in tracking the boring tool; and

a frequency selection arrangement, cooperating with said first arrangement, for detecting the selected one of said frequencies as a power-down frequency at a time when the transmitter is transferred from an operational state to an off state and for restarting the first arrangement at the power-down frequency upon switching from the off state to the operational state.

32. In a transmitter for use in a system in which a boring tool is moved underground in a region, said transmitter configured for transmitting a locating signal from the boring tool at least during the underground movement of the boring tool, a method comprising the steps of:

configuring the transmitter for transmitting the locating signal at a selected one of at least two frequencies for use in tracking the boring tool; and

with the transmitter above or on the surface of the ground, using a frequency selection arrangement, forming part of the transmitter, to determine the selected one of said frequencies based, at least in part, on a pitch orientation of the transmitter.

33. The method of claim 32 wherein said frequency selection arrangement includes a pitch sensor and the step of determining the selected one of said frequencies includes the step of reading the pitch orientation from the pitch sensor.

34. The method of claim 33 wherein said frequency selection arrangement reads the pitch sensor upon power-up of the transmitter to determine the selected one of said frequencies.

35. The method of claim 32 wherein said transmitter defines an elongation axis and a forward end for installation in the boring tool and is configured for transmitting at a low frequency and a high frequency and wherein said frequency selection arrangement selects the high frequency upon power-up of the transmitter with the forward end of the transmitter pointing approximately upward.

36. The method of claim 32 wherein said transmitter defines an elongation axis and a forward end for installation in the boring tool and said first arrangement is configured for transmitting at a low frequency and a high frequency and wherein said frequency selection arrangement selects the low frequency upon power-up of the transmitter with the forward end of the transmitter pointing approximately downward.

37. The method of claim 32 including the step of selecting a low one of said frequencies at approximately 1.5 kilohertz.

38. In a transmitter for use in a system in which a boring tool is moved underground in a region, said transmitter configured for transmitting a locating signal from the boring tool at least during the underground movement of the boring tool, a method comprising the steps of:

configuring the transmitter for transmitting the locating signal at a selected one of at least two frequencies for use in tracking the boring tool; and

with the transmitter above or on the surface of the ground, using a frequency selection arrangement, forming part of the transmitter, to determine the selected one of said frequencies based, at least in part, on an orientation parameter of the transmitter at power-up of the transmitter.

39. The method of claim 38 wherein said frequency selection arrangement includes a pitch sensor for measuring pitch of the transmitter as said orientation parameter and the step of determining the selected one of said frequencies includes the step of reading the pitch orientation from the pitch sensor.

40. In a transmitter for use in a system in which a boring tool is moved underground in a region, said transmitter defining an elongation axis configured for transmitting a locating signal from the boring tool at least during the underground movement of the boring tool, a method comprising the steps of:

configuring the transmitter for transmitting the locating signal at a selected one of at least two frequencies for use in tracking the boring tool;

with the transmitter above or on the surface of the ground, detecting a pitch orientation sequence of the elongation axis of the transmitter using a pitch sensing arrangement forming part of the transmitter; and

using a frequency selection arrangement, forming part of the transmitter, switching from the selected one of said frequencies to another one of said frequencies responsive to detection of the pitch orientation sequence.

41. The method of claim 40 wherein said detecting step detects, as said pitch orientation sequence, a first time interval during which the elongation axis of the transmitter is in a first pitch orientation, a second time interval during which the elongation axis is oriented having a different pitch orientation and a third time interval during which the elongation axis is oriented having a third pitch orientation.

42. The method of claim 41 wherein the first and third pitch orientations are within a particular predefined pitch range.

43. The method of claim 42 wherein the first and third pitch orientations are approximately horizontal in said particular predefined pitch range.

44. The method of claim 41 wherein the second pitch orientation is 45 degrees or more above horizontal.

45. The method of claim 41 wherein the first, second and third time intervals each include a duration that falls within a specified duration interval range.

46. The method of claim 38 further comprising the steps of detecting the selected one of said frequencies as a power-down frequency at a time when the transmitter is transferred from an operational state to a shutdown state and, thereafter, restarting in the operational state at the power-down frequency.

47. In a system including a boring tool which is moved underground in a region, said boring tool including a transmitter configured for transmitting a locating signal at least during the underground movement of the boring tool, a method comprising the steps of:

configuring the transmitter for transmitting the locating signal at a selected one of at least two locating frequencies for use in tracking the boring tool; and

using a frequency selection arrangement forming part of the transmitter, detecting the selected one of said locating frequencies as a transmitter power-down locating frequency at a time when the transmitter is switched from a transmitter operational state to a transmitter off state; and

restarting the transmitter at least initially configured to resume transmitting at the transmitter power-down locating frequency upon switching from the transmitter off state to the transmitter operational state.

48. The method of claim 47 wherein said system includes a locator for receiving the locating signal, said method further comprising the steps of:

configuring the locator for receiving the locating signal at any selected one of said locating frequencies for use in tracking the boring tool; and

using a control arrangement forming part of the locator, detecting the selected one of said frequencies as a power-down locating frequency at a time when the locator is powered down and, thereafter, powering up the locator at least initially configured for receiving the power-down locating frequency.

49. In a system in which a boring tool is moved through the ground in a region, said system including a locator for tracking the position of and/or guiding the boring tool as the boring tool moves through the ground, a method comprising the steps of:

transmitting a locating signal from the boring tool at a selected one of at least two frequencies for use in tracking the boring tool by receiving the locating signal with the locator; and

indicating the selected frequency of the locating signal to the locator using a frequency control arrangement which forms part of the transmitter.

50. The method of claim 49 wherein the step of indicating the selected frequency includes the step of transmitting a selected frequency indication from the transmitter on a carrier frequency that is separate from said locating signal.

51. The method of claim 50 wherein said boring tool moves underground having a pitch orientation and a roll orientation and said method further comprising the steps of sensing at least one of said pitch and roll orientations and transmitting the sensed pitch and roll orientations to the locator on said carrier frequency.

52. The method of claim 50 wherein said indicating step is repeated at predetermined intervals in time.

53. The method of claim 50 further comprising the steps of

detecting a command issued to the transmitter in a predetermined way to change the selected frequency to a different one of said frequencies using said frequency control arrangement;

switching the selected one of said frequencies to the different one of the frequencies; and

sending at least one indication to the locator, responsive to detection of said command, designating the different one of the locating frequencies that is selected.

54. The method of claim 53 wherein the step of detecting said command issued in said predetermined way includes the step of detecting a roll sequence to which said transmitter is subjected.

55. The method of claim 53 wherein the step of sending the indication is performed at least once prior to said switching step.

56. The method of claim 53 wherein the step of sending the indication is performed at least once following said switching step.

57. The method of claim 53 wherein the step of sending the indication is performed at least once prior to said switching step and performed at least once following said switching step.

58. The method of claim 53 further comprising the steps of:

using the locator, receiving the indication of the selection designating the different one of the locating frequencies; and

switching the locator to the different one of the locating frequencies responsive to the receipt of said indication.

59. The method of claim 58 wherein the locator includes a frequency control section and said step of switching the locator to the different one of the locating frequencies is automatically performed by said frequency control section upon receipt of said indication.

60. The method of claim 49 wherein said method further comprises the steps of

detecting a command issued to the transmitter in a predetermined way to change the selected locating frequency to a different one of said locating frequencies using said frequency control arrangement;

modulating said indication at least once on the locating signal for designating the selection of the different one of the locating frequencies to the locator; and

thereafter, switching the selected one of said locating frequencies of the transmitter to the different one of the locating frequencies.

61. The method of claim 60 wherein the step of detecting said command issued in said predetermined way includes the step of detecting a roll sequence to which said transmitter is subjected.

62. The method of claim 49 wherein said locating signal is transmitted from a transmitter received in said boring tool and said method includes the step of performing said indicating step at least once responsive to powering up said transmitter.

63. The method of claim 49 further comprising the steps of:

using a frequency selection arrangement forming part of the transmitter, detecting the selected one of said locating frequencies as a transmitter power-down locating frequency at a time when the transmitter is switched from a

transmitter operational state to a transmitter off state;

restarting the transmitter at least initially configured to resume transmitting at the transmitter power-down locating frequency upon switching from the transmitter off state to the transmitter operational state; and

repeating said indicating step at least once responsive to restarting the transmitter.

64. In a system including a transmitter configured for installation in a boring tool which is moved through the ground in a region, said system further including a locator for tracking the position of and/or guiding the boring tool using the locating signal, said transmitter comprising:

a first arrangement for transmitting a locating signal at a selected one of at least two locating frequencies for receipt by the locator; and

a frequency control arrangement for indicating the selected locating frequency of the locating signal to the locator.

65. The transmitter of claim 63 wherein the first arrangement and the frequency control arrangement are configured for cooperatively transmitting a selected locating frequency indication to indicate the selected locating frequency to the locator and for transmitting the selected locating frequency indication at least once prior to changing the selected locating frequency to the different locating frequency.

66. The transmitter of claim 64 wherein said frequency control arrangement is configured for transmitting a carrier frequency separate from said locating signal and for transmitting a selected locating frequency indication on said carrier frequency to indicate the selected frequency of the locating signal to the locator.

67. The transmitter of claim 66 wherein said boring tool moves underground having a pitch orientation and a roll orientation and wherein said transmitter further comprises an orientation sensing arrangement for sensing at least one of said pitch and roll orientations for cooperating with the frequency control arrangement to transmit the sensed pitch and roll orientations to the locator on said carrier frequency.

68. The transmitter of claim 66 configured for repeatedly sending the selected locating frequency indication to the locator at predetermined intervals in time.

69. The transmitter of claim 66 wherein the frequency control arrangement is configured to send the selected locating frequency indication at least once after changing the selected locating frequency to the different locating frequency.

70. The transmitter of claim 66 wherein the frequency control arrangement is configured to send the selected locating frequency indication at least once before and at least once after changing the selected locating frequency to the different locating frequency.

71. The transmitter of claim 66 wherein said frequency control arrangement is configured for detecting said command issued in said predetermined way including an arrangement for detecting a roll sequence to which said transmitter is subjected.

72. The transmitter of claim 64 wherein said frequency control arrangement is configured for indicating the selected locating frequency at least once responsive to powering up said transmitter.

73. In a system in which a boring tool is moved through the ground in a region, said system including a locating arrangement for tracking the position of and/or guiding the boring tool as the boring tool moves through the ground, said locating arrangement comprising:

a transmitter forming part of the boring tool for transmitting a locating signal at a selected one of at least two locating frequencies and for transmitting a frequency designation identifying the selected locating frequency of the locating signal; and

a locator configured for receiving the locating signal for use in tracking the boring tool and including a frequency tracking arrangement for switching the locator between different ones of the locating frequencies based on said frequency designation.

74. The locating arrangement of claim 73 wherein said locator is configured for automatically switching between said frequencies based on said frequency designation.

75. In a system in which a boring tool is moved underground in a region, said boring tool being configured for transmitting a locating signal therefrom at least during the underground movement of the boring tool for receipt by a locator for use in tracking the boring tool, a method comprising the steps of:

configuring the transmitter for transmitting the locating signal at a selected one of at least two locating frequencies;

using a control arrangement forming part of the locator, detecting the selected one of said locating frequencies as a power-down locating frequency at a time when the locator is initially powered down; and

thereafter, powering up the locator at least initially configured for receiving the power-down locating frequency.

76. In a system in which a boring tool is moved through the ground in a region, said system including a locating arrangement for tracking the position of and/or guiding the boring tool as the boring tool moves through the ground, said locating arrangement comprising:

a transmitter forming part of the boring tool for transmitting a locating signal at a selected one of at least two locating frequencies; and

a locator configured for receiving the locating signal for use in tracking the boring tool and including a frequency control arrangement for detecting the selected one of said locating frequencies as a locator power-down locating frequency at a time when the locator is initially powered down and, thereafter, for causing the locator to power-up at least initially configured for receiving the locator power-down locating frequency.

77. The locating arrangement of claim 76 wherein said transmitter is configured for sending an indication of the selected frequency of the locating signal to the locator.

78. The locating arrangement of claim 77 wherein said transmitter includes a frequency selection arrangement at least for detecting the selected one of said locating frequencies as a transmitter power-down locating frequency at a

time when the transmitter is switched from a transmitter operational state to a transmitter off state and for restarting the transmitter at least initially configured to resume transmitting at the transmitter power-down locating frequency upon switching from the transmitter off state to the transmitter operational state.

79. The locating arrangement of claim 77 wherein said frequency selection arrangement is configured for sending said frequency selection indication at least once responsive to restarting the transmitter.

80. In a tone decoder for decoding an incoming analog data stream containing at least one tone, a method comprising the steps of:

converting the incoming analog data stream to a binary data stream based on one switching threshold;

sampling the binary data stream over a sample period to establish a plurality of samples, each of which is characterized as a binary value, at a rate based on said tone; and

using said samples in a way which establishes at least an approximate magnitude of the tone for the sample period.

81. The method of claim 80 wherein said tone is characterized by a cycle time and said sampling step is performed at quarter wave intervals of each cycle time.

82. The method of claim 81 wherein the cycle time of said tone is selected from a range of potential cycle times and said method includes the step of varying a digital delay to cause the rate of sampling the binary data stream to occur at quarter wave intervals of the cycle time.

83. The method of claim 81 wherein the step of using the samples includes the steps of using alternating ones of said samples in contributing to a first value and a second value such that the first value and the second value are cooperatively indicative of at least the approximate magnitude of the tone.

84. The method of claim 83 wherein the binary value of each odd numbered one of the samples contributes to the first value by selectively performing one of incrementing, decrementing or maintaining the first value.

85. The method of claim 83 wherein the binary value of each even numbered one of the samples contributes to the second value by selectively performing one of incrementing, decrementing or maintaining the second value.

86. The method of claim 80 wherein said tone is characterized by a cycle time and said sampling step includes the steps of establishing a first, a second, a third and a fourth cycle sample during each cycle time, each of which is characterized in the form of said binary value and which cycle samples are approximately equally spaced apart in time during each cycle time to form the plurality of samples.

87. The method of claim 86 wherein said cycle samples are read at quarter wave intervals of the cycle time.

88. The method of claim 86 wherein the binary value of each cycle sample is either a zero or a one and the step of using the samples includes the steps of using alternating ones of said samples to contribute to a first value and a second value by

i) performing one of incrementing the first value when the first cycle sample binary value is one and maintaining the first value when the first cycle sample binary value is zero,

ii) performing one of incrementing the second value when the second cycle sample binary value is one and maintaining the second value when the second cycle sample binary value is zero,

iii) performing one of decrementing the first value when the third cycle sample binary value is one and maintaining the first value when the third second cycle sample binary value is zero, and

iv) performing one of decrementing the second value when the fourth cycle sample binary value is one and maintaining the second value when the fourth cycle sample binary value is zero.

89. The method of claim 88 including the step of representing each of the first and second values as a respective accumulated total measured in units and the steps including incrementing or decrementing the first and second values change the respective accumulated total by a unitary amount.

90. The method of claim 88 wherein the first value is an in-phase value and the second value is a quadrature value and wherein the approximate value of said tone is determined as $\sqrt{I^2+Q^2}$ where I is the in-phase value and Q is the quadrature value.

91. The method of claim 88 wherein the first value is an in-phase value and the second value is a quadrature value and wherein the approximate value of said tone is determined using a three line approximation of $\sqrt{I^2+Q^2}$ where I is the in-phase value and Q is the quadrature value.

92. The method of claim 88 wherein the first value is an in-phase value and the second value is a quadrature value and the approximate value of said tone is determined using a three line approximation including the three lines

I=KV,

Q=KV, and

$$I=\left[\sqrt{2}-\frac{1-K}{\sqrt{2}}\right]V-Q$$

where I is the in-phase value, Q is the quadrature value and K is a constant.

93. The method of claim 92 wherein K is equal to 0.974.

94. The method of claim 92 wherein K is equal to 1.0.

95. The method of claim 92 wherein the three lines are used in the form of the inequalities

$$I \geq KV$$

$$Q \geq KV, \text{ and}$$

$$I+Q \geq \left[\sqrt{2}-\frac{1-K}{\sqrt{2}}\right]V$$

by testing the inequalities and indicating that the tone is present when at least one of the inequalities is satisfied.

96. The method of claim 95 including the step of testing the inequalities using at least two different values of V such that the different values serve as a set of magnitude thresholds and, thereafter, indicating a relative approximate magnitude of the tone in relation to the set of magnitude thresholds.

97. In a tone detection arrangement for decoding an incoming data stream which contains at least one tone that is selectively present, a method comprising the steps of:

providing a plurality of digital filters each of which is tuned for detecting said tone over a filter interval from a filter start time to a filter stop time;

starting said digital filters in a staggered time relation with respect to one another so as to operate over a plurality of intervals that are in said staggered time relation with respect to one another including a plurality of said filter stop times which conclude the filter intervals in the staggered time relationship; and

determining an average magnitude of said tone responsive to the filter stop time of each filter.

98. The method of claim 97 further comprising the steps of:

restarting each of said digital filters after the filter stop time of each filter in said staggered time relation, and

determining the average magnitude of said tone responsive to the filter stop time of each restarted digital filter.

99. In a tone detection arrangement for decoding an incoming data stream that is received in a series of bit times and which contains at least one tone that is selectively present for the duration of each bit time, a method comprising the steps of:

providing a plurality of digital filters each of which is tuned for detecting said tone over a filter interval that is at least approximately equal in duration to the bit time from a filter start time to a filter stop time;

starting said digital filters in a staggered time relation with respect to one another so as to operate over a plurality of intervals that are in said staggered time relation with respect to one another including a plurality of said filter stop times which conclude in the staggered time relationship; and

determining an average magnitude of said tone responsive to the filter stop time of each filter.

100. The method of claim 99 further comprising the steps of:

restarting each of said digital filters after the filter stop time of each filter in said staggered time relation, and

determining the average magnitude of said tone responsive to the filter stop time of each restarted digital filter.

101. In a tone detection arrangement for decoding an incoming data stream that is received in sequential bit times and which contains at least one tone that is selectively present for the duration of each bit time, a method comprising the steps of:

a) providing a plurality of digital filters each of which is tuned for detecting said tone over a filter interval that is at least approximately equal in duration to the bit time from a filter start time to a filter stop time;

b) starting a first one of said digital filters at a first start time in relation to a particular bit time;

c) starting an additional one of said digital filters at an additional start time which occurs following a predetermined interval after said start time of the first digital filter such that a number of the predetermined intervals at least approximately equals the bit time in duration;

d) at the filter stop time of said first digital filter, determining at least an approximate magnitude of said tone

over the filter interval of the first digital filter;

e) at the filter stop time of the additional digital filter, determining at least an approximate magnitude of the tone over the additional filter interval of the additional digital filter.

102. The method of claim 101 wherein the predetermined interval is approximately equal to the bit time divided by a total number of digital filters which make up the plurality of digital filters.

103. The method of claim 101 further comprising the steps of:

f) starting a further additional one of said digital filters at a further additional start time which occurs following said predetermined interval after the start time of a last one of the additional digital filters to be started; and

g) at the filter stop time of the further additional digital filter, determining at least an approximate magnitude of the tone over the further additional filter interval of the further additional digital filter.

104. The method of Claim 103 further comprising the step of:

h) repeating steps f and g for each remaining one of the plurality of digital filters.

105. The method of claim 104 further comprising the step of:

i) repeating steps (b) through (h) after starting all of the plurality of digital filters.

106. The method of claim 101 including the step of outputting at least the approximate magnitude of the tone determined using the first and additional digital filters.

107. The method of claim 101 wherein said data stream is initially received in analog form and including the step of initially converting the incoming analog data stream to a binary data stream based on one switching threshold.

108. The method of claim 107 including the step of sampling the binary data stream using each digital filter during the filter interval for that digital filter to establish a plurality of samples, each of which samples is characterized as a binary value, at a rate based on said tone and using said samples in a way which establishes at least an approximate average magnitude of the selected tone for that filter interval.

109. The method of claim 108 wherein said tone is characterized by a cycle time and said sampling step is performed at one-quarter wave intervals of the cycle time.

110. The method of claim 109 wherein the step of using the samples includes the steps of

using alternating ones of said samples in contributing to a first value and a second value such that the first value and the second value are cooperatively indicative of at least the approximate magnitude of the tone.

111. The method of claim 110 wherein the step of determining the approximate magnitude of the tone includes the step of comparing the first and second values in a predetermined way against one or one more thresholds and outputting a magnitude indicative signal based on said one or more thresholds.

112. The method of claim 111 including the step of monitoring the magnitude indicative signal in relation to each digital filter to establish the presence of said tone over said bit time.

113. The method of claim 111 wherein said magnitude indicative signal is a binary representation of the magnitude of the tone in relation to one or more magnitude ranges.

114. A tone decoder for decoding an incoming analog data stream containing at least one tone, said tone decoder comprising:

a first arrangement for converting the incoming analog data stream to a binary data stream based on one switching threshold;

a second arrangement for sampling the binary data stream over a sample period to establish a plurality of samples, each of which is characterized as a binary value, at a rate based on said tone; and

a third arrangement for using said samples in a way which establishes at least an approximate magnitude of the tone for the sample period.

115. The tone decoder of claim 114 wherein said tone is characterized by a cycle time and said second arrangement is configured to sample the binary data stream at quarter wave intervals of each cycle time.

116. The tone decoder of claim 115 wherein the cycle time of said tone is selected from a range of potential cycle times and said second arrangement includes a variable digital delay for varying the rate of sampling the binary data stream to cause sampling to occur at quarter wave intervals of the cycle time.

117. The tone decoder of claim 115 wherein the third arrangement uses said samples in alternately contributing to a first value and a second value such that the first value and the second value are cooperatively indicative of at least the approximate magnitude of the tone.

118. The tone decoder of claim 117 wherein the third arrangement is configured such that the binary value of each odd numbered one of the samples contributes to the first value by selectively performing one of incrementing, decrementing or maintaining the first value.

119. The tone decoder of claim 117 wherein the third arrangement is configured such that the binary value of each even numbered one of the samples contributes to the second value by selectively performing one of incrementing, decrementing or maintaining the second value.

120. The tone decoder of claim 115 wherein said tone is characterized by a cycle time and said second arrangement is configured for reading said samples as a first, a second, a third and a fourth cycle sample during each cycle time, each of which is characterized in the form of said binary value and which cycle samples are approximately equally spaced apart in time durıng each cycle time to form the plurality of samples.

121. The tone decoder of claim 120 wherein second arrangement reads said cycle samples at quarter wave intervals of the cycle time.

122. The tone decoder of claim 120 wherein the binary value of each cycle sample is either a zero or a one and the third arrangement is configured for using alternating ones of said cycle samples to contribute to a first value and a second value by

i) performing one of incrementing the first value when the first cycle sample binary value is one and maintaining the first value when the first cycle sample binary value is zero,

ii) performing one of incrementing the second value when the second cycle sample binary value is one and maintaining the second value when the second cycle sample binary value is zero,

iii) performing one of decrementing the first value when the third cycle sample binary value is one and maintaining the first value when the third second cycle sample binary value is zero, and

iv) performing one of decrementing the second value when the fourth cycle sample binary value is one and maintaining the second value when the fourth cycle sample binary value is zero.

123. The tone decoder of claim 122 wherein said third arrangement includes a first and a second accumulator for use in storing each of the first and second values as a respective accumulated total measured in units and is configured for incrementing and decrementing the first and second values to change the respective accumulated total by a unitary amount.

124. The tone decoder of claim 122 wherein the first value is an in-phase value and the second value is a quadrature value and wherein the third arrangement is configured for determining the approximate value of said tone as $\sqrt{I^2 + Q^2}$ where I is the in-phase value and Q is the quadrature value.

125. The tone decoder of claim 122 wherein the first value is an in-phase value and the second value is a quadrature value and wherein the third arrangement is configured for determining the approximate value of said tone using a three line approximation of $\sqrt{I^2 + Q^2}$ where I is the in-phase value and Q is the quadrature value.

126. The tone decoder of claim 122 wherein the first value is an in-phase value and the second value is a quadrature value and wherein the third arrangement is configured for determining the approximate value of said tone using a three line approximation including the lines

$$I=KV,$$

$$Q=KV, \text{ and}$$

$$I = \left[\sqrt{2} - \frac{1-K}{\sqrt{2}}\right] V - Q$$

where I is the in-phase value, Q is the quadrature value and K is a constant.

127. The method of claim 126 wherein K is equal to 0.974.

128. The tone decoder of claim 126 wherein K is equal to 1.0.

129. The tone decoder of claim 126 wherein the third arrangement uses the three lines in the form of the inequalities

$$I \geq KV$$
$$Q \geq KV, \text{ and}$$
$$I + Q \geq \left[\sqrt{2} - \frac{1-K}{\sqrt{2}}\right]V$$

by testing the inequalities and indicating that the tone is present when at least one of the inequalities is satisfied.

130. The tone decoder of claim 129 wherein the third arrangement is configured for testing the inequalities using at least two different values of V such that the different values serve as a set of magnitude thresholds and, thereafter, for indicating a relative approximate magnitude of the tone in relation to the set of magnitude thresholds.

131. A tone detection arrangement for decoding an incoming data stream which contains at least one tone that is selectively present, said tone detection arrangement comprising:

a plurality of digital filters each of which is tuned for detecting said tone over a filter interval from a filter start time to a filter stop time;

a first arrangement for starting said digital filters in a staggered time relation with respect to one another so as to operate over a plurality of intervals that are in said staggered time relation with respect to one another including a plurality of said filter stop times which conclude the filter intervals in the staggered time relationship; and

a second arrangement for determining an average magnitude of said tone responsive to the filter stop time of each filter.

132. A tone detection arrangement for decoding an incoming data stream that is received in a series of bit times and which contains at least one tone that is selectively present for the duration of each bit time, said tone detection arrangement comprising:

a plurality of digital filters each of which is tuned for detecting said tone over a filter interval that is at least approximately equal in duration to the bit time from a filter start time to a filter stop time;

a first arrangement for starting said digital filters in a staggered time relation with respect to one another so as to operate over a plurality of intervals that are in said staggered time relation with respect to one another including a plurality of said filter stop times which conclude in the staggered time relationship; and

a second arrangement for determining an average magnitude of said tone responsive to the filter stop time of each filter.

133. A tone detection arrangement for decoding an incoming data stream that is received in sequential bit times and which contains at least one tone that is selectively present for the duration of each bit time, said tone detection arrangement comprising:

a) a plurality of digital filters each of which is tuned for detecting said tone over a filter interval that is at least approximately equal in duration to the bit time from a filter start time to a filter stop time;

b) a first arrangement for starting a first one of said digital filters at a first start time in timed relation to a particular bit time and for starting an additional one of said digital filters at an additional start time which occurs following a predetermined interval after said start time of the first digital filter such that a number of the predetermined intervals at least approximately equals the bit time in duration; and

c) a second arrangement for determining an average magnitude of said tone over the filter interval of the first digital filter at the filter stop time of said first digital filter and, thereafter, for determining the average magnitude of the tone over the additional filter interval of the additional digital filter at the filter stop time of the additional digital filter.

134. The tone detection arrangement of claim 133 wherein said predetermined interval is approximately equal to one-quarter of said bit time.

135. The tone detection arrangement of claim 133 wherein the predetermined interval is approximately equal to the bit time divided by a total number of digital filters which make up the plurality of digital filters.

136. The tone detection arrangement of claim 133 wherein the first arrangement is configured for starting a further additional one of said digital filters at a further additional start time which occurs following said predetermined interval after the start time of a last one of the additional digital filters to be started and the second arrangement is configured for determining the average magnitude of the tone over the further additional filter interval of the further additional digital filter at the filter stop time of the further additional digital filter.

137. The tone detection arrangement of Claim 136 wherein said first arrangement is further configured for sequentially starting each remaining one of the plurality of digital filters at consecutive ones of said predetermined interval and the second arrangement is further configured for sequentially determining the average magnitude of the tone over the filter interval of each of the remaining ones of the digital filters upon reaching the filter stop time of each filter.

138. The tone detection arrangement of claim 133 wherein said first and second arrangements are configured for cooperatively determining the approximate magnitude of said tone by sequentially using each one of the plurality of filters.

139. The tone detection arrangement of claim 138 wherein said second arrangement includes an output arrangement for outputting the approximate magnitude determined using each digital filter upon conclusion of the filter interval of each digital filter.

140. The tone detection arrangement of claim 133 wherein said data stream is initially received in analog form and said tone detection arrangement includes a comparator for initially converting the incoming analog data stream to a binary data stream based on one switching threshold and providing the binary data stream to said filters.

141. The tone detection arrangement of claim 140 wherein each digital filter is configured for sampling the binary data stream during the filter interval of that digital filter to establish a plurality of samples, each of which samples is characterized as a binary value, at a rate based on said tone and the second arrangement is configured for using said samples in a way which establishes at least an approximate magnitude of the selected tone for the filter interval of each digital filter.

142. The tone detection arrangement of claim 141 wherein said tone is characterized by a cycle time and each digital filter samples at one-quarter wave intervals of the cycle time.

143. The tone detection arrangement of claim 142 wherein the second arrangement uses alternating ones of said samples in contributing to a first value and a second value such that the first value and the second value are cooperatively indicative of at least the approximate magnitude of the tone.

144. The tone detection arrangement of claim 139 wherein said second arrangement is configured for comparing the first and second values in a predetermined way against one or more thresholds and outputting a magnitude indicative signal based on said one or more thresholds.

145. The tone detection arrangement of claim 144 including an output monitoring arrangement for monitoring the magnitude indicative signal in relation to each digital filter to determine the presence of said tone over said bit time.

146. The tone detection arrangement of claim 144 wherein said magnitude indicative signal is a binary representation of the magnitude of the tone in relation to one or more magnitude ranges.

147. In a system in which a boring tool is moved underground in a region, said boring tool being configured for transmitting a locating signal therefrom at least during the underground movement of the boring tool and for transmitting data relating to the boring tool as an encoded data stream including at least one tone, a locator comprising:

a locating arrangement for receiving the locating signal for use in tracking the boring tool;

a first arrangement for converting the incoming encoded data stream to a binary data stream based on one switching threshold;

a second arrangement for sampling the binary data stream over a sample period to establish a plurality of samples, each of which is characterized as a binary value, at a rate based on said tone; and

a third arrangement for using said samples in a way which establishes at least an approximate magnitude of the tone for the sample period.

148. In a system in which a boring tool is moved underground in a region, said boring tool being configured for transmitting a locating signal therefrom at least during the underground movement of the boring tool and for transmitting a data stream that is received in sequential bit times and which contains at least one tone that is selectively present for the duration of each bit time, a locator comprising:

a locating arrangement for receiving the locating signal for use in tracking the boring tool;

a plurality of digital filters each of which is tuned for detecting said tone over a filter interval that is at least approximately equal in duration to the bit time from a filter start time to a filter stop time;

a first arrangement for starting a first one of said digital filters at a first start time and for starting an additional one of said digital filters at an additional start time which occurs following a predetermined interval after said start time of the first digital filter such that a number of the predetermined intervals at least approximately equals the bit time in duration; and

a second arrangement for determining an average magnitude of said tone over the filter interval of the first digital filter at the filter stop time of said first digital filter and, thereafter, for determining the average magnitude of the tone over the additional filter interval of the additional digital filter at the filter stop time of the additional digital filter.

149. The locator of claim 148 wherein the first arrangement is configured for starting a further additional one of said digital filters at a further additional start time which occurs following said predetermined interval after the start time of a last one of the additional digital filters to be started and the second arrangement is configured for determining the average magnitude of the tone over the further additional filter interval of the further additional digital filter at the filter stop time of the further additional digital filter.